# PROCEEDINGS

OF THE

# ROYAL SOCIETY OF EDINBURGH.

1836. No. 8.

*Monday, 1st February* 1836.

SIR THOMAS M. BRISBANE, President, in the Chair.

The following Donations were presented:

No. 52. of the Map of the Ordnance Survey of Great Britain; published by the Board of Ordnance.—*By the Board.*

Proceedings of the Berwickshire Naturalists' Club. No. 3.—*By the Club.*

The following Communications were read:

1. On the Mathematical Form of the Gothic Pendant. By Professor Forbes.

The author commenced, by stating the general proofs of the knowledge of the principles of equilibrium displayed by Gothic architects in the structures (especially) of the pointed style. The adaptation of their edifices was to the combined ends of elegance and strength. The extension of this principle to the case of the Gothic pendant is the chief object of this paper. Sufficiency in point of strength, without redundancy of material, is considered by the author as the primary source of architectural beauty; which he has demonstrated to be the case when the depending Gothic drop is generated by the revolution of the logarithmic curve round its axis. The condition of maintenance of a depending body is, that the increment of the section may be in a constant ratio to the in-

crement of weight of the body to be sustained. This is shewn to be attained in the case of bare support, when the modulus of the logarithmic curve is equal to twice the modulus of cohesion of the substance of which the pendant is composed, in feet. Under these circumstances, the depending mass would be just within the limit of disruption, but its strength would be uniform throughout, and the tendency to separation would at no one point be greater than at another. It is not imagined that the Gothic architects could have had a mathematical knowledge of a curve, which was not attained till long after, but the degree of *tact* by which the eye is guided in the selection and adaptation of symmetrical forms seems quite capable of explaining such an approximation to theory, which, it is believed, has not before been noticed. Thus, a depending cylinder appears overloaded at its inferior extremity, a cone towards its middle, and so of all figures which are not concave outwardly.

2. On the occurrence of the Megalichthys Hibberti in a bed of Cannel Coal in the west of Fifeshire; with Observations on the supposed Lacustrine Limestone of Burdiehouse. By Leonard Horner, Esq. F.R.SS. L. & E., and F. G. S.

In a fragment of this kind of coal there was accidentally found a very fine specimen of a tooth, which the author considers to belong to the *Megalichthys Hibberti* of Agassiz. It is similar to some of those found in the limestone of Burdiehouse by Dr Hibbert, and is almost identical with that figured at p. 183 in Dr Hibbert's Memoir, in the 13th volume of the Society's Transactions; being about two inches long, and seven-eighths of an inch at the base, longitudinally striated, and covered with a shining enamel.

The coal in which it was found was brought from Halbeath, about two miles eastward of Dunfermline. It forms one of the regular coal-measures, being associated with sandstones, shales, clays, and beds of coal of ordinary qualities; the shells abounding with impressions of plants. The strata are subject to great disturbances, there being five faults in the space of half a mile. There are no trap-dikes, but there is an overlying mass of trap, which the author believes to be connected with a deep-seated dike; and it is probably to the intrusion of this igneous rock that the disturbances in the stratification are to be ascribed.

The occurrence of remains of the same sauroid fish that is found

in the limestone at Burdiehouse leads the author to inquire, whether there be any analogy between the two deposits: he thinks they are similar; not, however, that he believes there is a freshwater formation at Halbeath, but because he is of opinion that there is no ground for considering that such a formation exists at Burdiehouse, or that the strata there offer any exception to the usual phenomena presented by coal formations; that the bed of limestone is not, as Dr Hibbert maintains, of lacustrine origin, but presents only such characters as may be sufficiently accounted for on the supposition of the coal-measures having been deposited in an estuary, which is now the commonly received theory of the formation of coal deposits in general.

Dr Hibbert rests its lacustrine character on the absence of marine shells; and, in connection with that circumstance, on the abundance of land plants; the presence of what he conceives to be freshwater fishes; and a great profusion of the shells of what he calls a Cypris, one of those microscopic entomostraca which inhabit fresh water.

The author, on the other hand, maintains that the absence of marine shells is no proof, because it constantly happens that we find beds of limestone in which not a trace of an organized body can be found, alternating with others nearly wholly composed of them. That the same genera, and many of the same species of plants, are found throughout the whole of the carboniferous series, from the old red to the new red sandstone; that there is no ground for considering any of the fishes to have belonged to fresh water, but that, on the contrary, they are met with in the zechstein of Germany and the magnesian limestone of England, and frequently in other regular coal-formations; and that the shells of entomostraca are by no means a conclusive proof, as the shell of the Cytherina, which lives in sea water, cannot be distinguished from that of the Cypris.

3. Professor Forbes verbally communicated to the Meeting, that he had succeeded in proving the Circular Polarization of Heat, whether accompanied or unaccompanied by Light; when polarized heat is made to undergo two total reflections within a rhomb of rock-salt, the plane of total reflection being inclined 45° to the plane of primitive polarization.

*Monday, 15th February.*

DR HOPE, V. P. in the Chair.

The following Donations were presented:

The American Almanac and Repository of Useful Knowledge for the year 1836.—*Presented by the American Philosophical Society.*

Historical Account of Bills of Mortality, and the Probability of Human Life in Glasgow and other large Towns. By James Cleland, LL.D. &c. &c.—*By the Author.*

Proceedings of the Geological Society of London. No. 42.—*By the Society.*

Description of a Bronze or Cast-iron Columnal Light-House, with reference to a model of one-fourth the full size, designed for the Wolf Rock, situated between the Island of Scilly and the Land's-End. By Captain Samuel Brown, R. N.—*By the Author.*

Report respecting the Construction of Low-water Piers on the North and South Shores of the Frith of Forth, for the Fife and Mid-Lothian Ferries.—*By James Anderson, Civil-Engineer.*

Report on the present state of Leith Harbour, and the practicability of rendering available its Wet Docks, by means of a Deep-water Entrance, and a communicating Dock or Ship Canal. By James Anderson, Civil-Enginner.—*By the Author.*

The award of the Keith Prize to Professor Forbes having been announced by the Council on the 18th January, the medal was presented by the Vice-President, accompanied by an address to the following effect.*

The prize founded by our late estimable associate Mr Keith, whose ingenious contrivances for self-registering thermometers and barometers are recorded in our Transactions, is, by the regulation of his Trustees, to be adjudged biennially for the most important discovery communicated to the Royal Society, or in the event of such being wanting, for the best paper which shall have been presented to the Society in the space of two years on

* Printed by order of the Council.

a scientific subject. The Council, in discharge of the powers vested in them, have awarded unanimously the Keith prize for the last biennial period, to Professor Forbes, for his paper "On the Refraction and Polarization of Heat," which they consider to come under that class of communications, which contain discoveries important to science.

The Vice-president then observed, that the subject of heat is one so important to man, and so intimately connected with a variety of natural phenomena, that it has not failed to command no small degree of attention in all ages. That an intimate connexion subsists between Heat and Light, and that much discordance of opinion has subsisted respecting the nature of both. He next stated the various opinions entertained concerning them, and particularly respecting heat, and in historic order presented the views of Bacon, Boyle, Boerhaave, Stahl, and Black, and adverted to the discoveries of Black respecting latent and specific heat, and the successive labours of Irvine, Crawfurd, Wilke, Magellan, Lavoisier and Laplace, Dulong and Petit, in the same field.

Heat presents itself in two very different conditions; first when combined with matter, pervading bodies slowly, either by communication and conduction through and among its particles, or by the movements of the particles themselves; secondly, when radiated, moving through elastic fluids or empty space with vast velocity.

The first of these had been studied by the philosophers already named, and not long after by Rumford. To the second of these, viz. radiant heat, the subject of Professor Forbes's discovery called upon him more especially to allude, and to present a brief historic view.

The radiation of cold, and its reflection by metallic mirrors, was known to Baptista Porta in the sixteenth century; and observations were made on the radiation of heat, by the Florentine academicians, towards the middle of the seventeenth century, and by Marriotte in 1682. About the middle of the 18th century, Lambert published his works on pyrometry and photometry, which contained some of the first accurate experiments on this subject; and the facts of the difficult transmission and re-

flection of heat by glass, was pointed out by the Swedish chemist Scheele. Pictet of Geneva extended his experiments on the radiation and the reflection of the heat derived from boiling water, and our venerable associate Professor Prevost of the same place, established the doctrine of the mobile equilibrium of heat, in 1802. The triumph of this theory was found in the beautiful experiments of Dr Wells, on dew, in 1813.

Meanwhile, the experiments of Rumford and Leslie were corroborating and extending these general views, even although the doctrines of radiation were denied by the latter philosopher in all his writings. The passage of radiant heat through solid substances, such as glass, and through fluids, such as water, had long been admitted, in the case where light accompanied heat. But in the case of non-luminous heat, it was strenuously denied by Leslie, and others. The experiments of De la Roche proved that such was the fact, at least in the case of heat derived from terrestrial sources, and at the same time luminous. But this subject has received a vast enlargement by the recent experiments of Melloni, who has shewn that substances differ surprisingly in their permeability to heat, and that while some, such as alum, stop almost every incident ray, others, as rock-salt, transmit almost the whole of the heat, and that from whatever source derived.

The connection of light with heat, was too obvious and important to be overlooked. To Sir W. Herschel the world is indebted for the first great step in this curious inquiry. He examined the thermometric qualities of the spectrum formed from the sun's rays by a common prism of glass; and in 1800 announced the curious fact, that the heating power increases, not only from the violet to the red end of the spectrum, but *even beyond the latter*, indicating the existence of dark calorific rays. These experiments, though at first denied by some authors, were afterwards fully confirmed, and some anomalies which they presented, explained, by Robison, Englefield, Berard, Seebeck, and Melloni.

Heat, then, even unaccompanied by light, appears to be capable both of reflection and refraction. But new modifications of light, discovered of late years, require us to investigate how far

the analogy may be pursued. In 1802, Dr Young announced his remarkable discovery of the interference of the rays of light, or the power of two luminous rays, properly disposed, *to produce darkness* by their union. About the year 1808, Malus, a most eminent French philosopher and mathematician, discovered the remarkable modification which light undergoes by reflection from certain substances at certain angles. This modification may be easiest conceived by stating the fact, that light so reflected becomes incapable of undergoing a second reflection in certain positions of the reflecting surface, when common light would be reflected.

The corresponding experiment in the case of heat was tried by Berard, along with Malus, about the year 1811, and an account of them was published in 1817, in the *Memoires d'Arcueil.* They found, that when the solar beam was twice reflected in the manner just stated, the heat and light refused simultaneously to be reflected in certain positions of the second reflector. The same experiment was repeated with incandescent bodies, with the same result; and even, as stated by Berard, with bodies having temperatures beneath that of visible incandescence. These experiments were probably discontinued in consequence of the death of Malus, and the details were never published, if, indeed, they were ever carried to any great extent. The result has been, that Berard's conclusion seems not to have been generally adopted by the scientific world. The polarization of heat has remained amongst the doubtful facts in science. It has been adopted in scarcely any systematic works, whether British or foreign; and, of late years, direct evidence seemed to be entirely against it. Professor Powell of Oxford, repeatedly and fruitlessly, attempted to obtain Berard's result. Nobili of Florence (whose recent loss science has to deplore) attempted it likewise with the aid of his thermo-multiplier, an instrument admirably adapted for the measurement of small quantities of heat; and Melloni having failed to polarize even luminous heat by tourmalines, concurs in the conclusions of Powell and Nobili. The Vice-President then observed, that it was under these circumstances that the subject was undertaken by Professor Forbes, who, by means of arrangements differing from any that had be-

fore been used, has succeeded in completely establishing the polarization of heat under all the circumstances in which light is polarized, namely, by Reflection, Transmission, and Double Refraction, and that it is for the establishment of these facts that the Keith Prize has been awarded by the Council.

Dr Hope then stated that, in the ordinary case of the publication of papers, the Society holds itself in no degree responsible for the truth of the facts stated therein; but, in the adjudication of prizes, the case is different; and that, with regard to them, the Council are bound to be satisfied of the truth of the statements for which they award their prize. Several members of the Council had seen and satisfied themselves of the accuracy of Mr Forbes's leading experiments before the Keith Prize was awarded; and, some days ago, he deemed it right to request Mr Forbes to shew him the more important of these experimental demonstrations. This he succeeded in doing in a way which left upon his mind not the slightest doubt as to the truth of his results; the variations of temperature being so obviously displayed, as to prevent the slightest ambiguity as to the true source from which they are derived. The instrument employed in the research is the thermo-multiplier, of which the invention is due to Nobili, though it has been greatly improved for experimental purposes by Melloni. Professor Forbes has likewise increased greatly its power of indicating the more delicate effects by employing a telescopic apparatus, which enables him to measure a quantity of heat, perhaps not exceeding *one-fifteen hundredth* part of a degree of Fahrenheit.

That the Society may fully understand the nature of the proofs afforded by Mr Forbes's experiments, reference must be made to the correlative facts observed in the case of light.

When light undergoes reflection from glass at an angle of 56°, its physical character is found to be thus far altered, that it refuses to be a second time reflected by another plate of glass placed to receive the ray at the same angle of 56°, if the plane of incidence on the second glass be perpendicular to the plane of incidence on the first. The light is then wholly transmitted by the second plate. If the plane of incidence be the same for the

two plates, complete reflection takes place at the second plate. This illustrates polarization by *reflection.*

If a number of glass plates be used, and light *transmitted* obliquely through such a bundle of plates, it is in like manner found, that the emergent light is wholly transmitted by a second similar bundle placed parallel to the first, but is almost wholly reflected, and therefore *not* transmitted, when the second bundle is placed so that whilst the ray falls upon it at the same angle as upon the first, the plane of incidence on the second bundle being perpendicular to the plane of incidence upon the first bundle. This is polarization by *transmission* or *refraction.*

Lastly, It was observed before the close of the 17th century by Huyghens, that certain bodies, as Iceland spar, endowed with the property of double refraction, alter at the same time the character of the light in the two refracted rays. So that, if two sections similarly cut from a crystal of Iceland spar be placed upon one another in *conformable* positions, or the respective positions which they occupied on the crystal, the two rays will proceed through the second slice as they did through the first, and be refracted according to the same laws. But if the second slice be placed *unconformably* upon the first, or turned round a quarter of a circle, the ray, which at first was ordinarily refracted, is now extraordinarily refracted; and the ray, which at first was extraordinarily, is now ordinarily refracted. Now, it has been found that some crystals, such as tourmaline, possess the property, first, of dividing these rays, *and then of suppressing or absorbing one of them;* the result of which is, that when two tourmalines, cut as we have supposed, are placed *conformably,* the ray which was not suppressed by the first slice, still makes its way through the second; but, when placed *unconformably,* the ray transmitted by the first plate is wholly suppressed by the second. In the latter case, therefore, not a ray of light can penetrate the two plates. This is polarization produced by *double refraction.*

Now, all these modes of polarization have been recognised by Mr Forbes in the case of heat, and even in the case of heat wholly unaccompanied by light. The Vice-President announced that he had witnessed this in the most satisfactory manner in the

case of heat polarized by reflection and transmission, for which purposes, instead of glass, (which permits scarcely any non-luminous heat to penetrate it), Mr Forbes employs plates of mica, divided by a peculiar process into extremely thin laminæ.

But the analogies which he has established between light and heat do not stop here. It has been found in the case of light, that, when the two reflecting plates before spoken of, or the two crystals, are placed in *unconformable* positions, so that little or no light reaches the eye, we may, by interposing between the plates or the crystals a thin lamina of a doubly refracting substance (such as mica) in a certain position (relatively to its internal structure), cause a portion of light, which before was incapable of reaching the eye, to become capable of so doing. In other words, the polarized light, which at first was incapable of reflection or transmission at the second plate or crystal, now becomes capable of it; it has lost, to a certain extent, its character of polarization, or it is said to be depolarized.

Dr Hope stated, that he had seen this to be most completely effected in the case of heat, by Mr Forbes. A lamina of mica is interposed between the bodies used to polarize heat unconformably placed. When the lamina of mica has a certain position, no effect is produced beyond stopping a small portion of the heat, which would otherwise reach the thermometer; but when this interposed lamina is turned 45° in its own plane, a portion of the heat which before was incapable of reaching the thermometer in consequence of its polarization, is now capable of doing so, and the influx of heat is instantly indicated. The most striking exemplification of this result is found in the fact, which excited so much interest when communicated more than a year ago to the Society, that in certain cases the mere interposition of a piece of mica (in the proper situation), will cause an immediate indication of increased temperature, the mica *depolarizing* more heat than it *stops*. Since depolarization takes place only in consequence of double refraction, we have here another undoubted proof of the double refraction of heat.

The Vice-President terminated his general and rapid sketch, in which he alluded to the brilliant discoveries of Brewster, Arago, and Fresnel, respecting the polarization of light, by ob-

serving, that it would be needless for him to point out the important bearing of these facts on the question of the nature of heat, and its connection with light. He concluded in the following terms:—"It now only remains for me to present to Professor Forbes the medal which has been awarded to him for these discoveries. I believe that I shall be joined cordially by every member of the Society who now hears me, in the fervent wish that it may be the will of the Almighty Ruler, that his life may be long protracted, with vigour of mind and health of body to pursue the career in which he has made an advancement so honourable to himself, and reflecting lustre upon those great establishments, the University and the Royal Society, with which he is connected. I cannot doubt that he will persevere in this happy path with the same ardour and success which have hitherto accompanied his researches. Indeed, we have a gratifying proof that his zeal will not be impaired, nor his success less brilliant, from the discovery in the same field announced by him at the last meeting of the Society, of the Circular Polarization of Heat."

*Monday, 7th March.*

SIR T. MAKDOUGALL BRISBANE, President, in the Chair.

The following Donations were presented:

**Descriptions of the Inferior Maxillary Bones of Mastodons in the Cabinet of the American Philosophical Society, with Remarks on the Genus Tetracaulodon, &c. By Isaac Hays, M. D.—*From the Author.***

**Catalogue of Fossil Fish in the Collections of Lord Cole and Sir Philip Grey Egerton, arranged alphabetically, with references to the localities, strata, and published descriptions of the species. By Sir Philip Grey Egerton.—*From the Author.***

**Treatise on the more obscure Affections of the Brain, on which the nature and successful treatment of many chronic diseases depend. By A. P. W. Philip, M. D., F. R. S. L. & E., &c.—*From the Author.***

**Memoires de l'Académie Impériale des Sciences de St Petersbourg. (Sciences Mathematiques). Tome iii. Livrs. 2, 3, 4, 5, 6.**

Memoires de l'Académie Impériale des Sciences de St Petersbourg. (Sciences Mathematiques et Physiques). Tome i. Livr. 1, 2.

Do. do. (Sciences Politiques, &c.) Tome ii., liv. 6; et tome iii. liv. 1.

Do. do. (Memoires présentés pars divers Savans). Tome ii. Livrs. 4, 5, et 6.

Recueil des Actes de la Séance publique de l'Academie Imperiale des Sciences de St Petersbourg, tenue le 29. Decembre 1834. —*From the Imperial Academy.*

The following Papers were read:

1. On the Non-Hellenic portion of the Latin Language. By the Venerable Archdeacon Williams.

The line of argument went to shew, that the Umbri were one of the most ancient nations of Italy. That they, through their colonies or entire tribes, entered deeply into the composition of the primitive population of Rome. That, according to ancient authorities, these Umbri were the descendants of the "Veteres Galli." That these Veteres Galli were of the same race and blood as the present Cumbri of Wales, Cornwall, and Brittany. That hence it is probable, that the ancient language still preserved among these may have entered easily into the composition of the language of the Romans. That the names of rivers, mountains, cities, lakes, districts, &c. in central Italy, and in all the countries over which the Sabellian tribes, and their cognate race the Veneti, diffused themselves, is likely to convert this probability into certainty. That the question concerning the ancient population of Italy has never yet been satisfactorily treated; that it never can be, unless the examiner is well acquainted not only with the language, but also the literature of Greece and Rome, and with at least one type or form of the several Teutonic and Celtic languages. That a slight acquaintance with other forms is also very desirable. That the writer professes to be conversant with Greek, Roman, and Cumbrian literature, and to a certain extent with the Anglo-Saxon, and that he knows something of the Gaelic and Basque tongues. That no examination of indexes can avail, owing to the peculiar character of the Cumbrian tongue, in which a person ignorant of the principles of its grammar might suspect that there was nothing fixed, while, on the contrary, it is the most fixed and indestructible of all languages. That the vocabularies of the Latin and Cumbrian languages are strikingly si-

milar, although their grammars are radically different. That the work of comparing the two languages etymologically would be easy, had it not been for the long stay of the Romans in Gaul and Britain, which must be supposed to have made a deep impression upon the language of the natives. That nevertheless much Latin words exist, to the primary meaning of which the Cumbrian scholar alone possesses the key, and that a long list of words belonging to such a class must prove that some cognate branch of his language must have entered into the original composition of the Latin tongue. That the strength of the proof must depend upon the extent of the induction.

2. On the Sources and Composition of the different kinds of Gamboge. By Dr Christison.

3. On the Botanical Origin of Gamboge. By Dr Graham.

Gamboge was first made known by Clusius about the commencement of the seventeenth century, as a concrete juice from China. About the middle of the same century, Bontius conceived he had traced it to a particular species of *Euphorbia*, growing in Java and in Siam; from the latter of which countries the whole gamboge of commerce was at that time obtained. About the close of that century Hermann announced that gamboge was produced by two species of trees growing in Ceylon, which have been since often confounded together, but which are now designated by the names *Garcinia Gambogia*, and *Stalagmitis Gambogioides*. About the middle of last century, gamboge was referred by Linnæus to the former of these plants, and his reference was generally admitted. But about thirty years later, Professor Murray of Göttingen conceived he had traced it satisfactorily from the specimens collected by Koenig in Ceylon, and information obtained by the same botanist in Siam, to a new species which he called *Stalagmitis gambogioides*.

Dr Graham shows, from specimens and drawings sent from Ceylon, both by Mrs Colonel Walker to himself, and by David Anderson Blair, Esq. to the late Dr Duncan, that the plant producing Ceylon gamboge is neither *Garcinia gambogia*, as Linnæus thought, nor *Xanthochymus ovalifolius*, as conjectured by Dr Wight and Mr Arnott, nor *Stalagmitis gambogioides*, according to Murray and Koenig, but is a species described by Lamarck and Gärtner under the name of *Garcinia* or *Mangostana morella*, although it differs

from all of these genera in the structure of its stamens, and, therefore, probably ought to be considered a new genus among those producing a gambogioid juice.

Dr Christison proved, that, at the present time, Ceylon gamboge is not an article of European commerce, and that the whole gamboge of the markets of this country comes, as in the time of Bontius, from China. After mentioning the analysis of fine gamboge made by Braconnot in France and John in Prussia, he stated the following as the mean composition of the several varieties of gamboge he has hitherto examined:—

Pipe gamboge of Siam:

| | |
|---|---|
| Resin, | 72.2 |
| Arabin, | 23.0 |
| Moisture, | 4.8 |
| | 100.0 |

Cake gamboge of Siam:

| | |
|---|---|
| Resin, | 64.8 |
| Arabin, | 20.2 |
| Fecula, | 5.6 |
| Lignin, | 5.3 |
| Moisture, | 4.1 |
| | 100.0 |

Ceylon gamboge sent by Mrs Colonel Walker:

| | |
|---|---|
| Resin, | 70.2 |
| Arabin, | 19.6 |
| Fibre of wood and bark, | 5.6 |
| Moisture, | 4.6 |

Ceylon gamboge, adhering to a specimen of the bark sent by Mr David Anderson Blair:

| | |
|---|---|
| Resin, | 75.5 |
| Arabin, | 18.3 |
| Cerasin, | 0.7 |
| Moisture, | 4.8 |
| | 99.3 |

The proportion of the gum to the resin varied somewhat in each variety, but never differed more than 2 per cent. from the means given above.

The author added, that he had found the resin to be the active principle of gamboge.

He inferred from the composition of the different kinds of gamboge, and other circumstances detailed in his paper, that the cake gamboge of Siam is not entirely a natural production, but a manufactured article: that Ceylon gamboge, if freed from incidental fibrous matter, corresponds almost exactly with Siam gamboge: that, therefore, they are probably produced by the same plant: that Ceylon gamboge possesses precisely the same medicinal properties: and that this variety, if more carefully collected, may, in all probability, be applied with equal advantage to every economical purpose which is at present served by the finest pipe gamboge of Siam.